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Alginate versus addition silicone: What is the best material for removable partial dentures?

Alginato versus silicone de adição: Qual o melhor material para prótese parcial removível?

Alginato versus silicona de adición: ¿Cuál es el mejor material para las prótesis parciales removibles?

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Abstract
Objective: The objective of this study was to create a narrative literature review article, covering two different types of materials: silicone and alginate, with the aim of seeing which is the best material to compose a removable partial denture. Methodology: The searches were carried out in PUBMED Central, Web of Science, VHL/BIREME, Brazilian CAPES, Scielo and using the Google Academy portal. A total of 24 articles were acquired that address the benefits and harms of using silicone and alginate in removable partial dentures, in addition to their differences. We consult periodicals and books, aiming to obtain more reliable information on the topic. In order to carry out a literature review, the vision of Mattos (2015) was used to structure the article. Results: During the study, it was seen that addition silicone is widely considered the best material due to its high precision, excellent ability to reproduce details and superior dimensional stability, however alginate is more economical and easier to use, it is more suitable for preliminary impressions and situations where extreme precision is not essential.
Keywords: Removable partial denture; Silicones; Alginates.

Resumo
Objetivo: O objetivo deste estudo foi fazer um artigo de revisão de literatura narrativa, abordando dois tipos de materiais diferentes: silicone e alginato, com objetivo de ver qual é o melhor material para compor uma prótese parcial removível. Metodologia: As buscas foram realizadas na PUBMED Central, Web of Science, BVS/BIREME, CAPES brasileira, Scielo e utilizando o portal Google Academy. Foram adquiridos um total de 24 artigos que abordam sobre os benefícios e malefícios do uso de silicone e alginato nas próteses parciais removíveis, além de suas diferenças. Realizamos consultas de periódicos e livros, visando obter mais informações confiáveis sobre o tema. Tendo em vista realizar uma revisão de literatura, a visão de Mattos (2015) foi utilizada para estruturar o artigo. Resultados: Ao decorrer do estudo,

foi visto que o silicone de adição é amplamente considerado o melhor material devido à sua alta precisão, excelente capacidade de reprodução de detalhes e superior estabilidade dimensional, entretanto o alginato é mais econômico e fácil de usar, é mais adequado para impressões preliminares e situações onde a precisão extrema não é essencial.
Palavras-chave: Prótese parcial removível; Silicones; Alginatos.

Resumen
Objetivo: El objetivo de este estudio fue crear un artículo narrativo de revisión de la literatura, que abarque dos tipos diferentes de materiales: silicona y alginato, con el objetivo de ver cuál es el mejor material para componer una prótesis parcial removible. Metodología: Las búsquedas se realizaron en PUBMED Central, Web of Science, BVS/BIREME, CAPES brasileña, Scielo y mediante el portal Google Academy. Se adquirieron un total de 24 artículos que abordan los beneficios y perjuicios del uso de silicona y alginato en prótesis parciales removibles, además de sus diferencias. Consultamos publicaciones periódicas y libros, con el objetivo de obtener información más confiable sobre el tema. Para realizar una revisión de la literatura se utilizó la visión de Mattos (2015) para estructurar el artículo. Resultados: Durante el estudio se vio que la silicona de adición es ampliamente considerada el mejor material debido a su alta precisión, excelente capacidad para reproducir detalles y estabilidad dimensional superior, sin embargo el alginato es más económico y fácil de usar, es más adecuado para preliminares. impresiones y situaciones en las que la extrema precisión no es imprescindible.
Palabras clave: Prótesis parcial removible; Siliconas; Alginatos.

1. Introduction

During the learning phase of dentistry students, students are often faced with the crucial question of taking an impression to create removable partial dentures (RPDs). This issue also often exists among the same teachers in prosthetics clinics, namely: some argue that alginate is the best option as it can adequately copy the dental arches that will receive a PPR, while others argue that, despite it being able to be carried out with alginate, addition silicone is undoubtedly the best material because of its structural stability.

In dental practice, the choice of material for mouth impressions is crucial to guarantee the quality and precision of removable partial dentures. Among the available materials, alginate and addition silicone stand out for their distinct characteristics and clinical application. Alginate is widely used due to its low cost, ease of handling and comfort for the patient. However, it presents limitations in terms of precision and dimensional stability, requiring the impressions to be cast immediately to avoid distortions. On the other hand, addition silicone, or polyvinylsiloxane, is recognized for its high precision, excellent dimensional stability and durability, characteristics that make it ideal for high-fidelity moldings, although at a higher cost and more complex manipulation.

The aim of this study was to carry out a literature review article, covering two different types of materials: silicone and alginate, with the aim of seeing which is the best material to compose a removable partial denture.

2. Methodology

During the construction of this narrative literature article, readings and contextualizations were carried out using the work of Mattos (2015), which explains how to construct a literature review, serving as a basis to clarify the differences between the different types of reviews, together with the article by Rother (2007), who structured the methodology used and the type of literature review assigned in this work. Associated with online research using data available in VHL/BIREME and PUBMED Central. The searches were carried out on other platforms, such as: Portal CAPES Journal, Science Direct, Web of Science, and also on Google Scholar, the last platform used to collect the articles. Physical books and periodicals were also used in the search.

3. Results

3.1 Alginate in Dental Impressions

Alginate has been a material used in dentistry for decades. Before the appearance of addition silicone, this irreversible hydrocolloid was considered the most used impression material in prostheses due to its ease of handling, cost and good clinical results. As for the chemical composition, sodium (or potassium) alginate is the main component that forms an irreversible hydrocolloid gel that can only be used once, as it will be destroyed after removing the plaster, which it will be applied to.

This copying material can be defined as a polymer derived from seaweed (brown algae) which, when mixed with water and a crosslinking agent, allows the formation of an elastic gel. Calcium sulfate (or other calcium salts) acts as protagonists in this chemical reaction. Crosslinking agents can be defined as substances that have a low molar mass and reactive functional groups capable of allowing the formation of inter- or intra-polymer chain bonds (Carr & Brown, 2011).

These react with sodium alginate to form alginate gel. Sodium silicate (or other gelling retardants) controls the setting time, called gelling, increasing working time, at the same time allowing the dentist to manipulate and apply the material before it starts to gel. Trisodium phosphate (or other pH regulators) regulates the pH of this mixture, ensuring that the gelation reaction occurs in a controlled manner, allowing the clinical operator to notice the change in its consistency during the actual handling of the material.

Another component is zinc oxide, which improves the consistency and resistance of this material, providing the necessary mass for mixing, while also helping to define details of the area to be molded, which in the vast majority of cases are the dental arches. Another active ingredient is the filling agent called diatomine (or diatomaceous earth), which improves the consistency and compressive strength of the alginate in impressions. In addition to what was mentioned above, added pigments and dyes provide the material's characteristic color, facilitating its visualization and identification of the material's structural and visual changes during its application (Khasanov & Mansurov, 2022; Garcia et al., 2023).

In order to facilitate clinical applicability in the acceptance of the material during patient impressions, flavorings and flavors further improve acceptability, providing a more pleasant taste and aroma during the procedure itself, together with humectant agents, which improve mixing as well as its handling, helping to disperse the powdered components homogeneously in the water, thus ensuring a uniform and smooth dough.

When alginate powder is mixed with water, a chemical reaction occurs between sodium alginate and calcium sulfate, resulting in the formation of an alginate gel. This gel captures the impression of the patient's mouth, allowing the creation of a detailed mold for making prosthetics. Nevertheless, Errors during manipulation have been pointed as the main fact for flaws and defects since the forties (Sknner & Pomes, 1946). Some additional considerations must be carried out, as can be seen below:

1- Setting Time: Setting time may vary depending on the specific alginate formula, which can be adjusted by adding or modifying the amount of retarders or accelerators.

2- Dimensional Stability: Although alginate is easy to use, its dimensional stability is a limitation, requiring molds to be poured quickly to avoid distortion.

These components and their functions have allowed alginate to be a popular and practical choice for preliminary impressions and study models in dental practice. Like any material, it has advantages and disadvantages as we will see below:

3.1.1 Advantages of Alginate

1. Craig and Powers (2002) highlight that alginate is widely used due to its low cost and ease of handling, making it accessible and convenient for use in dental offices. It's the main

2. Anusavice (2003) emphasizes the rapid mixing and short working time of alginate, which provides comfort to the patient and efficiency to the dentist.
3. Johnson and Craig (2011) note that alginate is generally well tolerated by patients as it is gentle and does not cause significant discomfort during impression taking.
4. Powers and Sakaguchi (2012) note that alginate has a good ability to reproduce details when handled correctly, being effective for preliminary impressions.
5. Rosenstiel, Land, and Fujimoto (2015) highlight the ease of use of alginate, which does not require expensive or complex equipment for its application.

3.1.2 Disadvantages of Alginate

1. Phillips (2003) points out that the main limitation of alginate is its inadequate dimensional stability, leading to distortions if the impressions are not cast immediately.
2. Craig and Powers (2002) mention the lower precision of alginate compared to more advanced materials, such as addition silicones.
3. Anusavice (2003) notes that alginate is susceptible to variations in humidity and temperature, which can affect the quality of the impression.
4. Johnson and Craig (2011) highlight that alginate is not suitable for impressions that require prolonged storage, due to its tendency to undergo syneresis and imbibition.
5. Powers and Sakaguchi (2012) report that alginate can present difficulties in obtaining fine details in complex areas of the dental arch.
6. Therefore, the advantages and disadvantages imply indications and contraindications for the material, as follows:

3.1.3 Indications for Alginate

1. Craig and Powers (2002) suggest the use of alginate for preliminary impressions and for making study models, where extreme precision is not crucial.
2. Anusavice (2003) recommends alginate for orthodontic impressions, where fast and efficient impressions are required.
3. Johnson and Craig (2011) recommend alginate for making temporary dentures and for preliminary impressions of removable dentures.
4. Powers and Sakaguchi (2012) highlight that alginate is appropriate for pediatric patients due to its quick application and comfort.

3.1.4 Alginate contraindications

1. Phillips (2003) contraindicates the use of alginate in definitive impressions for fixed prostheses and implants, where precision and dimensional stability are essential.
2. Craig and Powers (2002) advise against alginate in situations where the impression cannot be cast immediately, due to the risk of distortion.
3. Anusavice (2003) warns against the use of alginate in environments with high humidity and temperature variations, which can compromise the quality of the impression.
4. Johnson and Craig (2011) contraindicate alginate for patients with intolerance to the material or allergies to any of its components.

3.2 Addition Silicone to Dental Impressions

Addition silicone, also called addition silicone (polyvinylsiloxane), is an elastic impression material, used in the manufacture of molds and dental prostheses (Eckert & Lammie,1996). What sets it apart is its ability to not undergo significant deformation over time, ensuring more precise and reliable impressions, a fact that makes it a material with a much higher reproduction capacity than alginate. However, it cannot be handled with latex gloves, but can be handled with nitrile gloves. Its molding technique, however, is more complex than that of alginate. It is carried out using the double impression technique, or relining technique, in which two materials of different viscosities are used. The procedure consists of carrying out a preliminary molding with the heavy material that is manipulated with the hands and applied to the surface to be molded. Then, a material with a more fluid consistency is used and applied to the internal face of the first stage. This more fluid material, after setting, offers excellent and stable copying capacity (Hyde et al., 2011).

3.2.1 Advantages of Addition Silicone

1. Craig and Powers (2002) highlight that addition silicone offers excellent precision and dimensional stability, making it ideal for impressions that require high fidelity.
2. Anusavice (2003) highlights that the material presents an excellent reproduction of details, capturing even the smallest anatomical contours.
3. Powers and Sakaguchi (2012) note the superior dimensional stability of filler silicone, allowing impressions to be stored for extended periods without distortion.
4. Rosenstiel, Land, and Fujimoto (2015) highlight tear resistance, which minimizes loss of detail during removal of the impression from the patient's mouth.
5. Johnson et al. (2011) observe that addition silicone has low polymerization shrinkage, which contributes to the precision of moldings.
6. Walker and Petrie (2005) point out the ease of disinfection of silicone and addition, which maintains its properties even after the application of disinfectant agents.
7. Craig, Powers and Wataha (2000) mention the compatibility of addition silicone with a wide variety of plasters and resins for models.

3.2.2 Disadvantages of Addition Silicone

1. Craig and Powers (2002) mention that addition silicone is more expensive compared to other impression materials such as alginate.
2. Anusavice (2003) notes that the handling of addition silicone can be more complex, requiring specific equipment for mixing and application.
3. Powers and Sakaguchi (2012) point out that the polymerization time can be longer, which can increase the patient's chair time.
4. Rosenstiel, Land, and Fujimoto (2015) report that some addition silicones can release hydrogen gases after molding, requiring a waiting time before pouring the model.
5. Walker and Petrie (2005) highlight that addition to the mold holder may be insufficient, requiring the use of specific adhesives to guarantee stability during molding.

3.2.3 Addition Silicone Indications

1. Craig and Powers (2002) recommend addition silicone for definitive impressions of fixed prostheses, such as crowns and bridges, where precision is critical.
2. Anusavice (2003) suggests the use of addition silicone in implant impressions due to its dimensional stability and detailed reproduction.
3. Powers and Sakaguchi (2012) recommend addition silicone for impressions of partial and complete removable dentures, ensuring a precise fit.
4. Rosenstiel, Land, and Fujimoto (2015) recommend addition silicone for cases of high anatomical complexity, where fine details are essential.
5. Johnson et al. (2011) highlight the use of addition silicone in orthodontics for precise and long-lasting impressions.

3.2.4 Contraindications of Addition Silicone

1. Craig and Powers (2002) contraindicate the use of addition silicone in situations where cost is a limiting factor, such as in low-budget practices.
2. Anusavice (2003) advises against the use of addition silicone in preliminary impressions, where high precision is not necessary.
3. Powers and Sakaguchi (2012) warn against the use of added silicone in patients with allergies to the material's components.
4. Rosenstiel, Land, and Fujimoto (2015) recommend caution when using addition silicone in environments where polymerization may be affected by high temperatures.
5. Walker and Petrie (2005) contraindicate the use of addition silicone in molds that need to be poured immediately, due to the possible release of hydrogen gases.

4. Discussion

The choice of a dental material for impressions of removable partial dentures is, undoubtedly, a fundamental issue for the success of a prosthesis that adapts well to the patient's arch, avoiding costly repetitions for the professional and facilitating customer satisfaction.

Alginate is often used in preliminary dental impressions due to its ease of use and affordable cost, although its dimensional stability is limited. On the other hand, addition silicone is preferred for definitive impressions due to its high precision, excellent reproduction of details and dimensional stability that is unquestionably superior to that of alginate. The choice between these materials depends on the specific needs of each clinical case, balancing cost, practicality and precision required to manufacture these types of removable prostheses, as well as other fixed ones. The work of Chiarello, Tiossi, Lapria Faria, Silveira Rodrigues and Ribeiro (2006), already mentioned that the main disadvantage of irreversible hydrocolloids are low tear strength, low capacity for reproducing tiny little details when compared to elastomeric materials.

Regardless of the material to be chosen, some peculiar situations may appear in prosthetic clinics, or integrated or Extension clinics, during the learning curve of students at Higher Education Institutions (HEIs). The big issue revolves around the costs of materials and the speed they can present during the manufacture of a prosthesis, focused on the need for temporary adaptation to the number of clinics available per semester. Without a shadow of a doubt, alginate is the material that loses out in terms of its ability to copy the hard and soft structures of the dental arches during reproduction in plaster. However, in some

specific situations, it can be used, in simpler cases, as long as the casting of the plaster inside the negative presented by the impression is done immediately.

The work of Craig and Powers (2002) as well as Powers and Sakaguchi (2012) is very clear regarding the indications for addition silicone. Their considerations refer to the recommendation of addition silicone for definitive impressions of prostheses where precision is critical. However, they suggest the use of alginate for preliminary impressions and for making study models, where extreme precision is not crucial. The issue, according to their conclusions, is the ability to reproduce in the final stage of molding. The authors also reiterate the unquestionable issue regarding the lower precision of alginate compared to addition silicone. Their ideas are corroborated by Powers and Sakaguchi (2012), by whinkler (2002) as well as Nogueira, Antoniazzi and Bortoluzzi, (2019), who state that, despite the good ability to reproduce details when handled appropriately, alginate is in fact effective, but for preliminary impressions. For this purpose, they also add that it may show deficiencies in obtaining fine details, in difficult-to-access areas of the dental arch.

The low polymerization shrinkage led Johnson et al. (2011) and Puri and Dixit (2015) state that addition silicone is more precise in impressions, while Walker and Petrie (2005) add that the ease of disinfection remains present in the properties of this material, even after the application of disinfectant agents. Rosenstiel, Land, and Fujimoto (2015) emphasize resistance to tearing, one of the factors that may cause fragmentation of the plaster when removed from the tray; a fact that minimizes the loss of detail when removing the impression from the patient's mouth Preiskel (2011) in his book also agrees with the precision of impression concerning the low polymerization shrinkage of addition silicone. Similar conclusions have been reached by McCabe and Walls (2008), Phoenix et al. (2012); Rosenstiel et al. (2006).

The difficulties in using addition silicone are due to its excellent reproducibility and post-set structural stability. The work of Anusavice (2003) states that manipulation in two stages is richer in details and requires greater dexterity and experience from the professional or student, completing the report by stating that as a result of this, the patient's time in the chair may take longer , a fact that may be more or less relevant, depending on the needs of each patient.

Thus, as final considerations, this review comes to the understanding that reproduction capacity is the critical issue that separates both materials when deciding what type of prosthesis will be made.

5. Conclusion

Alginate is widely used in dental impressions due to its ease of use and cost-effectiveness. Its main components include sodium alginate and calcium sulfate, which acts as a cross-linking agent. Although alginate is effective for preliminary impressions and study casts, its limited dimensional stability requires immediate casting to prevent distortion, making it less ideal for impressions that require high precision and fine detail. For this purpose, addition silicone seems to be the material of first choice because of its ability to reproduce the hard and soft structures of the oral cavity. The literature review suggests that, for the fabrication of removable partial dentures (RPDs), addition silicone is widely considered the best material due to its high precision, excellent ability to reproduce details and superior dimensional stability. Although alginate is more economical and easier to use, it is best suited for preliminary impressions and situations where extreme precision is not essential.

From this, it is seen that more studies should be carried out on both types of materials, providing more information on the subject, with a view to carrying out case reports that address the great difference of each material in daily clinical life, its benefits and harms. Seeking to obtain data on which is the best type to be used in each specific case and objective during daily care.

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